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Polychlorinated Biphenyl Distribution and Sources in Aquatic Plants in the Eastern AL-Hammar Marshes, Iraq

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Abstract

Aquatic habitats are contaminated by harmful, persistent organic pollutants called polychlorinated biphenyls, or PCBs. The purpose of this study was to ascertain the distribution of PCBs in two common aquatic plants from the East Hammar Marsh in southern Iraq: *Phragmites australis* and *Typha domingensis*. Seasonally, the plants were harvested from five locations between winter 2021 and autumn 2022. Using GC-MS, samples were extracted and examined for 19 PCB congeners. Seasonal fluctuations were noted in the total PCB values, which varied from 0.01-2.95 ng/g and 0.02-4.55 ng/g dry weight in *Phragmites* and *Typha*, respectively. According to plant physiology, mean ΣPCB levels were lowest in the summer (0.16 ng/g in Phragmites; 0.21 ng/g in Typha) and highest in the spring (1.29 ng/g in Phragmites; 2.29 ng/g in Typha). Overall, *Typha* had a greater mean annual accumulation of ΣPCBs (3.17 ng/g) than *Phragmites* (2.57 ng/g). The findings indicate PCB contamination in Iraqi marshes, with uptake varying seasonally and by plant species. This study provides baseline data on PCBs in Iraqi marsh plants for future biomonitoring and phytoremediation research.

Keywords: Bioaccumulation, Iraq marshes, Phytoremediation, Polychlorinated biphenyls

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Introduction

Large amounts of contaminants accumulate in aquatic plant tissues. Owing to their rapid growth and high biomass, the roots absorb the most toxic pollutants. As a result, aquatic plants are thought of as organisms that are used for monitoring pollution and can be used for biomonitoring the biological response of plants to environmental changes (Kristanti & Hadibarata, 2023). It plays a significant role in the functioning of environmental systems because it allows some plants to accumulate significant amounts of different pollutants without showing any obvious negative effects. Biomarkers can generally be identified by their capacity to accumulate particular or selected constituents, tolerate toxicity without sensitivity to the buildup of contaminants, are abundantly present in the ecosystem being studied, can be found in a variety of situations, and are easy to recognize (Partow & UNEP, 2001).

Consequently, ecosystems may be threatened by environmental changes. Plants use different processes to accumulate contaminants and thus sustain their growth (Aziz et al., 2006). The accumulation of contaminants by plants is a complex issue. The species and biomass of aquatic plants and phytoplankton can affect the bioaccumulation and distribution of PCBs as well as the concentrations of persistent organic pollutants (POPs) in aquatic ecosystems. Vegetation serves as a pollutant collection medium and a significant organic pollutant carrier in the food chain (Xia et al., 2022).

Phytoremediation is a type of bioremediation defined by the environmental concept of using living organisms that can reduce pollution levels through vital-metabolic processes. Some plants can remove or reduce pollution levels through metabolic processes, resulting in the removal or sequestration of various pollutants. These plants are referred to as biological filters because they accumulate pollutants and toxins in their tissues and act as filters to remove contaminants from water bodies. Members of the genus *Phragmites* may be among the largest plants used for this purpose (Li & Sun, 2022).

The plant *P. australis,* or common reed, is one of the species of emergent plants with the greatest global distribution. The adaptability of this plant indicates its competitive nature. Due to the great intraspecific variability and changeable phenotypic makeup of the common reed, the plant demonstrates a wide ecological amplitude. Additionally, the plant shows a strong ability to adapt to what are thought of as unfavorable environmental conditions. For many years, this plant has been used in phytoremediation to clean up various types of wastewaters. *Phragmites australis* is superior to other aquatic plants in this regard because of its strong capacity to accumulate different nutrients, heavy metals, and micropollutants (Milke et al., 2020).

This plant has a hollow, thick, woody stem and rhizomes or roots, and can reach a density of 200 roots per square meter. At a depth of 1-3 feet, roots can grow below the surface of the soil. The flowers are shaped like bundles of thorns with soft bristles, in contrast to tapered, pointed leaves. The reed plant reproduces either vegetatively by growing a network of rhizomes or by producing seeds that are distributed in the air and water. Reed is one of the most prevalent plants worldwide. It is found in North and South America as well as in Asia, Africa, Europe, and Australia. It flourishes around the margins of lakes, marshes, and rivers. Additionally, they can be found in situations with high levels of pollution, relative salinity, humidity, and heat. The reed plant prevents soil erosion through the growth of rhizomes at good depths under the soil and is used in the paper industry, as animal fodder, and other uses (AL-Zabad, 2021).

Aquatic vegetation is one of the features of marshes that are well known for their variety of uses. They have a direct impact on several creatures, including people, animals, and fish. They also contribute to the economy, industry, and tourism (Al-Atbee 2018; Patel and Kanungo 2010). Owing to their extensive vegetative cover and high production, plants are used in environmentally sound technologies that help clean the environment and safeguard the health of water. As a result, many nations have turned to employing inexpensive plants to address a variety of environmental issues by creating artificial wetlands and cultivating them with various aquatic plants that are beneficial for enhancing the ecosystem (UNEP, 2001). Aquatic wetlands can be divided according to habitat and vegetative sites from the water surface into three major types (Al-Hadeethi, 2016; Al-Abbawy et al., 2021): emergent plants, floating plants, and submerged plants, the green parts of which appear above the water surface, whereas the roots are submerged in the substrate, with the ability to support themselves without substrate, except in the early stages of growth, such as *T. domingensis* (common cattail) and *Phragmites australis* (common reed). Reeds and sedges are widespread plants in all parts of the world except for the North and South Poles. Both species are found in Iraq in humid habitats, some of which are very tall and others medium in height. They are considered indigenous plants in Iraq (Alwan, 2006), and reed and sedge plants are biennial plants. They reach heights of 3 and 4 m, respectively, and their leaves are long. They are considered anchor plants, meaning that the plants have their roots in the water, whereas most of the plant's body is located outside the water. In addition, both types live in water with high or low organic sediments (Wenerick et al., 2020).

Method and Materials

Study areas

The samples were collected seasonally from five stations to determine the regional and seasonal variation in PCBs in marshes of southern Iraq, as shown in Figure 1. They were washed several times with marsh water to remove adherent particulates as much as possible, wrapped in aluminum foil, and analyzed for PCBs.

PCBs were extracted from the plants according to the method of Vorkamp *et al*. (2012), where the plant samples were dried and ground using an electric mill (Fritsch) and then sifted through a sieve with a diameter of 63 µm. Five grams of crushed reed plant was placed in a thimble, and the PCBs were extracted using the Soxhlet Intermittent Extraction device using 100 ml of a mixture of hexane: methylene chloride (v/v1:1) for 48 h at a temperature not exceeding (40) °C; the extract was then left to cool, and the saponification process was carried out for two hours by adding (15) ml of methanolic potassium hydroxide solution diluted MeOH(KOH) (4M) and left until cool; then, all the contents were transferred to a separating funnel, and 50 ml of hexane/methyl chloride (v/v1:1) was added to the mixture, which was shaken well and left for a period of time until the solution separated into two layers. The bottom soaped layer was removed and discarded, and the unpurified top organic layer containing PCBs was taken and then passed through a chromatographic separation column containing glass wool at the bottom and 2 g of silica gel, topped with a layer of alumina (2 g) to remove fatty acid residues, and 2 g of anhydrous sodium sulfate to remove water. The extract was collected in a glass container, labelled, allowed to dry, and then properly closed until measurement was performed with GC-MASS.

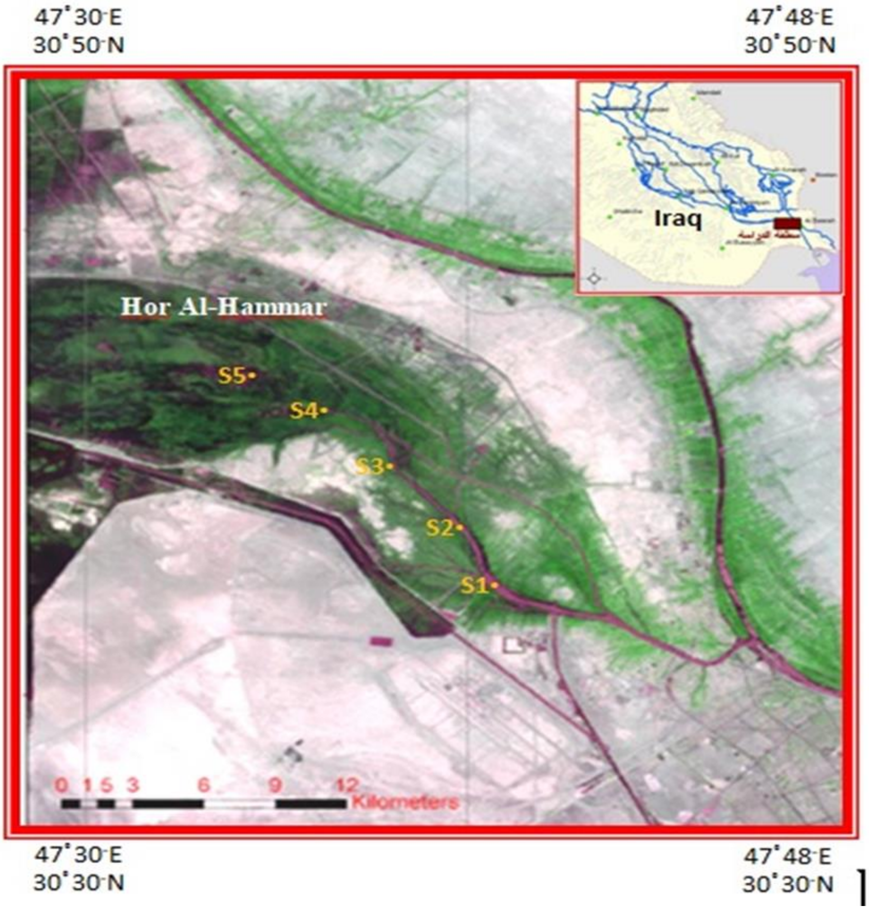

Figure 1: Map of the study area.

Data Analysis

Two-way analysis of variance (ANOVA) to test for significant differences in PCB concentrations between the two plant species and among the four seasons, as well as any interaction effects. SPSS software was used in this analysis

Result and Discussion

The results showed that the highest concentration of PCBs in phragmites australis

(2.95ng\l) in autumn of PCBs52 and the lowest concentration of PCBs44(0.02ng\l) in spring. The highest mean PCBs concentration was(1.29ng\l) in spring and the lowest mean (0.16ng\l) in summer, as shown in (Table 1, Figures 2 and 3) during the four season.

Table (1) Concentration and types of PCBs in *Phragmites australis* during the four seasons, respectively.

Compound	Winter	Spring	Summer	Autumn
PCB 18	0.12	0.08	0.16	1.36
PCB-29(IS)	0	0	0.18	0.05
PCB 31	0.72	2.63	0.26	0.27
PCB 28	0.08	0.59	0	0.86
PCB 44	0.01	0.02	0.29	0.51
PCB 52	0.51	0.96	0.02	2.95
PCB 101	1.34	0.36	0.27	1.19
PCB 141	0	0.42	0.21	0.22
PCB 149	0	0.55	0	0.29
PCB 138	1.33	0.78	0	0.3
PCB 153	1.53	1.59	0.31	0.81
PCB 189	0	0.59	0.16	0.14
PCB 194	0.6	0.51	0.17	2.2
Total	6.24	9.06	3.05	11.15
Mean	0.48	1.29	0.16	0.64
±SD	0.582	0.718	0.115	±2.257

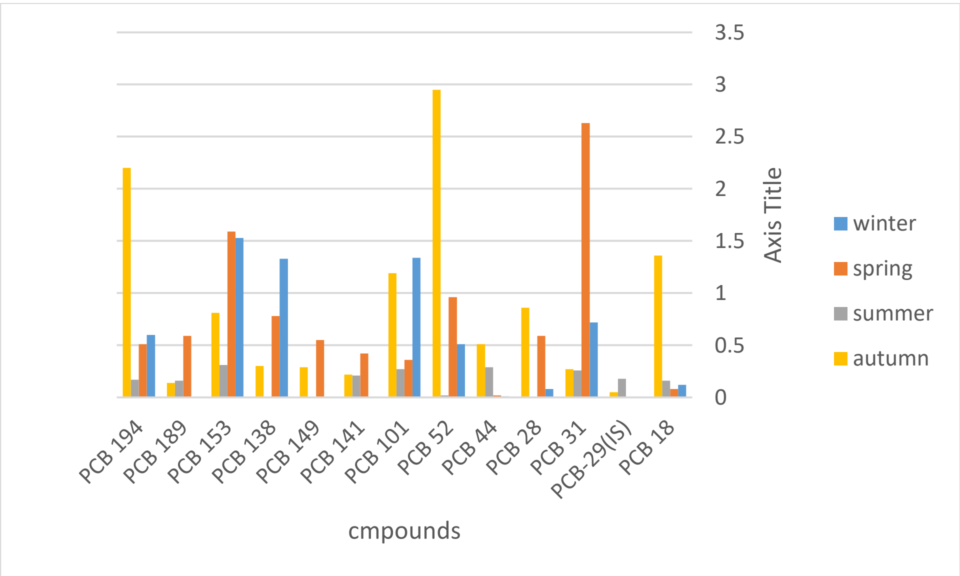

Figure 2: Concentration and types of PCBs in *P. australis* during the four seasons.

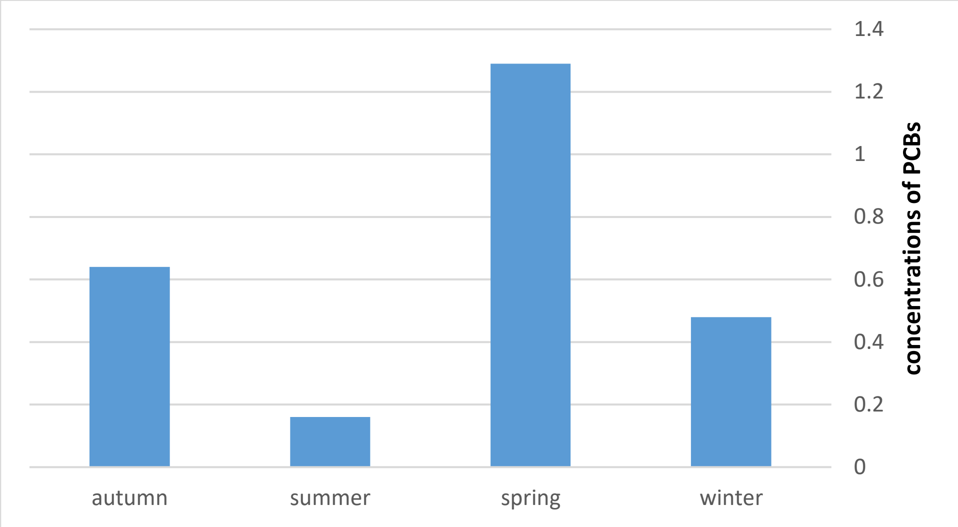

Figure 3: Mean concentrations of PCBs in *P. australis* during the four seasons.

The results showed the highest concentration of PCBs in *Typha domingensis* (3.22ng\g) of PCBs189 in spring and the lowest concentration of PCBs-29(ls) (0.02ng\g) in winter. The highest mean PCBs concentration was(1.129ng\g) in spring and the lowest mean (0.21ng\g) in summer, as shown in (Table 2, Fig4 and Fig5).

T. domingensis recorded the highest mean of PCBs (3.17ng\l) and *Phragmites australis* recorded the lowest mean (2.57ng\l) as shown in (Figure 6).

Table 2: Concentration and types of PCBs in *T. domingensis* during the study period.

Compound	Winter	Spring	Summer	Autumn
PCB 18	0.47	0.1	0.17	0.55
PCB-29(IS)	0.02	0.12	0	1.62
PCB 31	1.67	0.99	0.13	1.48
PCB 28	0.07	0.2	0	0.16
PCB 44	0.03	0.11	0.49	0. 12
PCB 52	1.82	2.77	0.85	2.65
PCB 101	1.48	2.33	0.25	2.98
PCB 141	0	0.16	0.17	0.07
PCB 149	0	0.07	0	0.88
PCB 138	2.36	1.52	0.3	0.09
PCB 153	2.09	0	0.24	0.19
PCB 189	0	4.55	0.06	0.29
PCB 194	0	3.09	0.11	1.99
Total	10.02	16	2.78	13.07
Mean	0.77	2.29	0.21	1.005
±SD	0.946	1.5	0.237	1.041±

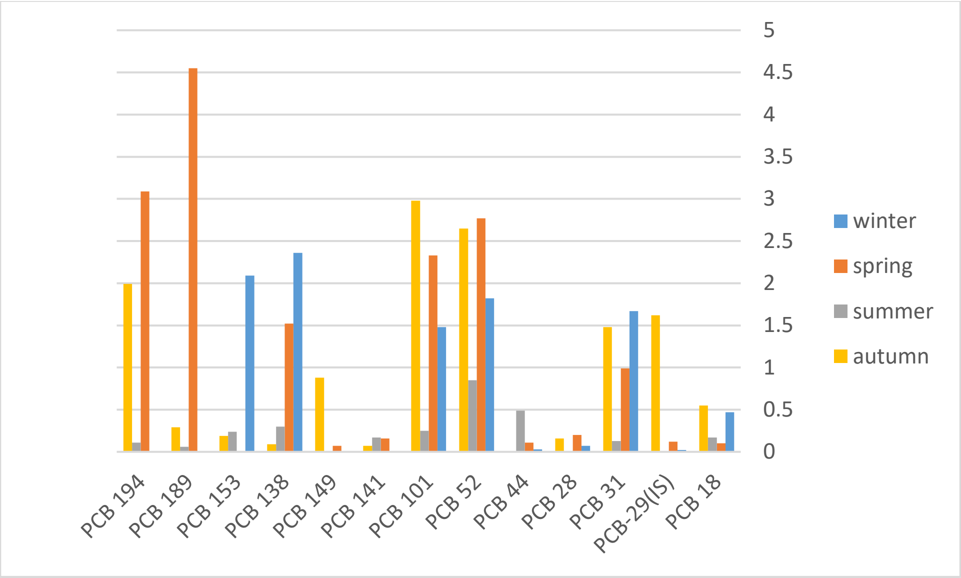

Figure 4: Concentration and types of PCBs in *T. domingensis* during the study period

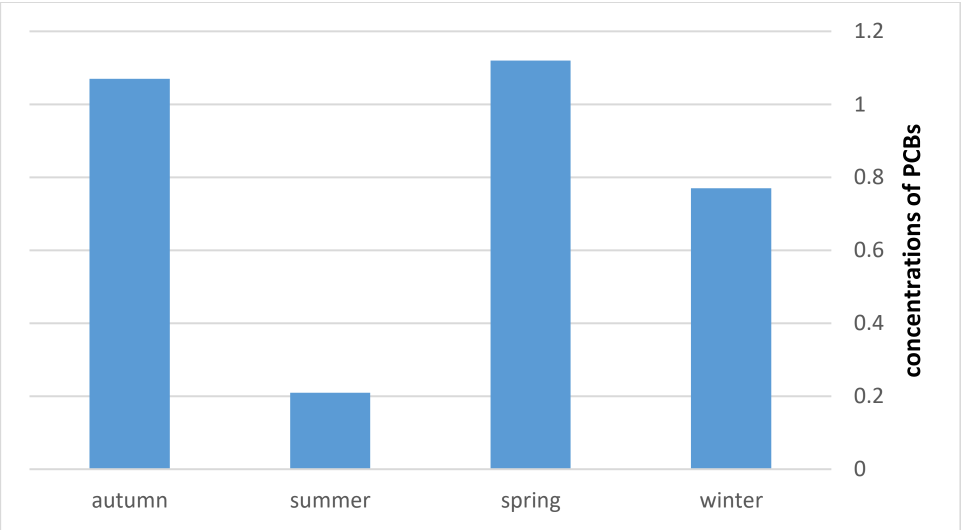

Figure 5: Mean concentrations of PCBs in *T. domingensis* during the study period.

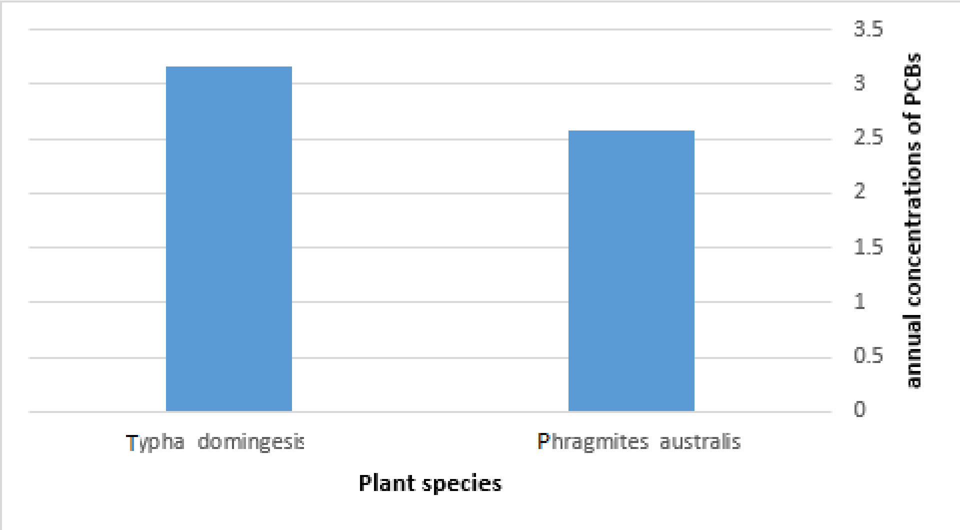

Figure 6: The mean annual concentrations of PCBs compounds for the studied plants during the study period.

Some aquatic plants can eliminate or reduce pollution levels through metabolic processes, which leads to the removal or decomposition of various pollutants. As well as by secreting enzymes in the root area that can lead to bioremediation processes (Al-Zabad, 2021)

Aquatic plants are utilized as a useful indication and biological indicator of element pollution in the aquatic ecosystem because they have the capacity to absorb elements and nutrients from the water column and sediments and accumulate them in their tissues (Al-Atbee, 2018), here were distinct seasonal differences in the concentration of PCBs in the studied aquatic plants, which can be attributed to a variety of environmental factors, including the ability of aquatic plants to accumulate PCB differently in their tissues, the uptake of them depended on plant species, and the differences in the age states of plants. Many plant species store their constituents in their stems or roots, which may explain why the contents of plant species vary. Additionally, the depth of the water column influences the accumulation of components in aquatic plant tissues.

The results in both types of plants studied showed that the highest concentrations were in the spring and the lowest concentrations were in the summer, and this may depend on the tissue and physiological composition of the plants and the bioaccumulation characteristic of both types, these plants bloom in the spring Both types can grow in water with high organic sediments (Iabal et al.,2022)

The higher concentrations in the Typha plant than in the reed plant were due to the tissue structure of both types of plants, especially the tissue structure of the roots.

The sedge plant *Typha domingensis* is one of the most prominent aquatic plants used for biological removal because of its ability to absorb nutrients from the bottom and the water column and its possession of rhizomes that provide a larger surface area for the breakdown of pollutants by bacteria. The reed plant also secretes enzymes capable of decomposing organic materials in the water, leading to changes in concentrations between the two plants during different locations and seasons. This study is the first of its kind in the marshes of Iraq and provides information for future research.

Conclusions:

These plants can concentrate such compounds in their tissues during different seasons, despite the difference in their accumulation in both species, and can be used as biological markers to measure these compounds in their tissues.

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توزيع ثنائي الفينيل متعدد الكلور ومصادره في النباتات المائية في هور الحمار الشرقي، العراق

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المستخلص

الموائل المائية ملوثة بملوثات عضوية ضارة وثابتة تسمى ثنائي الفينيل متعدد الكلور ، أو ثنائي الفينيل متعدد الكلور .كان الغرض من هذه الدراسة هو التأكد من توزيع مركبات ثنائي الفينيل متعدد الكلور في اثنين من النباتات المائية الشائعة من هور الحمر الشرقي في جنوب العراق *Phragmites australis* :و *Typha domingensis.* موسميا، تم جمع النباتات من خمسة مواقع بين شتاء *2021* وخريف *2022.* باستخدام *GC-MS* ، تم استخراج العينات وفحصها بحثا عن *19* متجانسا من متجانسات ثنائي الفينيل متعدد الكلور .ولوحظت تقلبات موسمية في القيم الكلية لثنائي الفينيل متعدد الكلور، التي تراوحت بين *0.01* و *2.95* نانوغرام/غرام و0 *4.55-02.*نانوغرام/غرام بالوزن الجاف في القصب والبردي على التوالي .وفقا لفسيولوجيا النبات ، كان متوسط مستويات ثنائي الفينيل متعدد الكلور في أدنى مستوياته في الصيف *0.16)* نانوغرام / غرام في القصب ؛ *0.21* نانوغرام /غرام في البردي (وأعلى في الربيع *1.29)* نانوغرام / غرام في القصب ؛ *2.29* نانوغرام / غرام في البردي .(وعموما، كان لدى البردي متوسط تراكم سنوي أكبر لمركبات ثنائي الفينيل متعدد الكلور *3.17)* نانوغرام/غرام (من القصب *2.57)* نانوغرام/غرام .(وتشير النتائج إلى تلوث ثنائي الفينيل متعدد الكلور في الأهوار العراقية، مع تفاوت الامتصاص موسميا وحسب الأنواع النباتية .توفر هذه الدراسة بيانات أساسية عن مركبات ثنائي الفينيل متعدد الكلور في نباتات الأهوار العراقية من أجل الرصد البيولوجي وبحوث المعالجة النباتية في المستقبل.

الكلمات المفتاحية: التراكم الأحيائي, أهوار العراق, المعالجة النباتية, ثنائي الفينيل متعدد الكلور